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Standard Specification for QUENCHED AND TEMPERED STEEL BOLTS AND STUDS¹

This standard is issued under the fixed designation A 449; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This specification covers the chemical and mechanical requirements for quenched and tempered, medium carbon steel bolts and studs 3 in. and under in diameter for general applications where high strength is required.

1.2 Suitable nuts are covered in Specification A 563. Unless otherwise specified, the grade and style of nut shall be as follows:

Fastener Size and Surface Finish	Nut Grade and Style ⁴
¼ to 1½ in., plain (or with a coating of insufficient thickness to require over-tapped nuts)	B, hex
over 1½ to 3 in., plain (or with a coating of insufficient thickness to require over-tapped nuts)	A, heavy hex
¼ to 3 in., galvanized (or with a coating thickness requiring over-tapped nuts)	C, heavy hex

⁴ Nuts of other grades and styles having specified proof load stresses (Specification A 563, Table 3) greater than the specified grade and style of nut are suitable.

NOTE 1—The values stated in inch-pound units are to be regarded as the standard.

2. Applicable Documents

2.1 ASTM Standards:

A 153 Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware²

A 370 Methods and Definitions for Mechanical Testing of Steel Products.³

A 563 Specification for Carbon and Alloy Steel Nuts⁴

2.2 American National Standards:⁵

ANSI B1.1 Unified Screw Threads

ANSI B18.2.1 Square and Hex Bolts and Screws

3. Material and Manufacture

3.1 Steel for bolts and studs shall be made by the open-hearth, basic-oxygen, or electric-furnace process.

3.2 The bolts and studs shall be heat treated by quenching in a liquid medium from above the transformation temperature and then tempering by reheating to a temperature of not less than 800°F (427°C).

3.3 Threads of bolts and studs shall be rolled, cut, or ground.

3.4 When specified, galvanized fasteners shall be hot-dip galvanized in accordance with the requirements of Class C of Specification A 153. When specified by the purchaser to be mechanically galvanized, fasteners covered by this specification shall be mechanically zinc-coated, and the coating shall conform to requirements for Class 50 of Specification B 454, or to the coating thickness, adherence, and quality requirements for Class C of Specification A 153.

NOTE 2—When the intended application requires that assembled tension exceeds 50 % of minimum bolt or stud proof load, an anti-galling lubricant may be needed. Application of such a lubricant to nuts and a test of the lubricant efficiency are provided in Supplementary Requirement S1 of Specification A 563 and should be specified when required.

4. Chemical Requirements

4.1 The bolts and studs shall conform to requirements as to the chemical composition specified in Table 1.

4.2 Product analyses may be made by the

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² Annual Book of ASTM Standards, Part 3.

³ Annual Book of ASTM Standards, Parts 1 to 5 and 10.

⁴ Annual Book of ASTM Standards, Parts 1 and 4.

⁵ May be obtained from American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.

purchaser from finished material representing each lot. The chemical composition thus determined shall conform to the requirements prescribed for product analysis in Table 1.

4.3 Application of heats of steel to which bismuth, selenium, tellurium, or lead has been intentionally added shall not be permitted.

5. Mechanical Requirements

5.1 Bolts and studs shall not exceed the maximum hardness specified in Table 2. Bolts less than three diameters in length and studs less than four diameters in length shall have hardness values not less than the minimum nor more than the maximum hardness limits required in Table 2, as hardness is the only requirement.

5.2 Bolts and studs $1\frac{1}{4}$ in. in diameter or less, other than those excepted in 4.1, shall be tested full size and shall conform to the tensile strength and either the proof load or yield strength requirements specified in Tables 3 and 4.

5.3 Bolts and studs larger than $1\frac{1}{4}$ in. in diameter as above, other than those excepted in 5.1, shall preferably be tested full size and when so tested, shall conform to the tensile strength and either the proof load or yield strength requirements specified in Tables 3 or 4 respectively. When equipment of sufficient capacity for full-size testing is not available, or when the length of the bolt or stud makes full-size testing impractical, machined specimens shall be tested and shall conform to the requirements of Table 5. In the event that bolts are tested by both full size and by the machined test specimen methods, the full-size test shall govern if a controversy between the two methods exists.

5.4 For bolts and studs on which both hardness and tension tests are performed, acceptance based on tensile requirements shall take precedence over low readings of hardness tests.

6. Dimensions

6.1 Unless otherwise specified, the bolts shall be finished hexagon head with dimensions conforming to the latest issue of ANSI B18.2.1.

6.2 Studs shall have dimensions conforming to those specified by the purchaser.

6.3 Unless otherwise specified, threads shall be Coarse Thread Series as specified in the

latest issue of ANSI B1.1, and shall have Class 2A tolerances.

6.4 Unless otherwise specified, bolts to be used with nuts or tapped holes that have been tapped oversize, in accordance with Specification A 563, shall have Class 2A threads before hot dip or mechanical galvanizing. After galvanizing, the maximum limit of pitch and major diameter may exceed the Class 2A limit by the following amount:

Diameter, in.	Oversize Limit, in. (mm) ^A
Up to $\frac{1}{16}$, incl.	0.016(0.41)
Over $\frac{1}{16}$ to 1, incl.	0.021(0.53)
Over 1	0.031(0.79)

^A These values are the same as the minimum overlapping required for galvanized nuts in Specification A 563.

6.5 The gaging limit for bolts shall be verified during manufacture or use by assembly of a nut tapped as nearly as practical to the amount oversize shown above. In case of dispute, a calibrated thread ring gage of that same size (Class X tolerance, gage tolerance plus) is to be used. Assembly of the gage, or the nut described above, must be possible with hand effort following application of light machine oil to prevent galling and damage to the gage. These inspections, when performed to resolve disputes, are to be performed at the frequency and quality described in Table 6.

7. Test Methods

7.1 Bolts and studs shall be tested in accordance with Supplement III of Methods A 370.

7.2 The wedge test shall be applicable only to square and hexagon head bolts.

7.3 Studs shall be tested by the Axial Tension Method as described in S11.1.3.1, Supplement III of Methods A 370.

8. Number of Tests and Retests

8.1 The requirements of this specification shall be met in continuous mass production for stock, and the manufacturer shall make sample inspections to ensure that the product conforms to the specified requirements. Additional tests of individual shipments of material are not ordinarily contemplated. Individual heats of steel are not identified in the finished product.

8.2 When specified in the order, the manufacturer shall furnish a test report certified to be the last completed set of mechanical tests for each stock size in each shipment.

8.3 When testing on a lot basis is specified on the purchase order, a lot, for purposes of selecting test samples, shall consist of all material of one type, that is, bolts or studs having the same nominal diameter and length offered for inspection at one time. From each lot, the number of tests for each specified property shall be as follows:

Number of Pieces in Lot	Number of Samples
800 and less	1
Over 800 to 8 000, incl	2
Over 8 000 to 22 000, incl	3
Over 22 000	5

8.4 Should any sample fail to meet the requirements of a specified test, double the original number of samples from the same lot shall be retested for the requirement(s) in which it failed. All the additional samples shall conform to the specification or the lot shall be rejected.

8.5 If any test specimen shows defective machining, it may be discarded and another specimen substituted.

9. Workmanship

9.1 The bolts and studs shall be commercially smooth and free from burrs, laps, seams, cracks, and other injurious material or manufacturing defects which would make them unsuitable for the intended application.

10. Marking

10.1 Bolt heads shall be marked with 3 radial

lines 120 deg apart and with a symbol identifying the manufacturer. Markings may be raised or depressed at the option of the manufacturer.

11. Inspection

11.1 If the inspection described in 8.2 is required by the purchaser, it shall be specified in the inquiry and contract or order.

11.2 The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of manufacturer's works that concern the manufacture and testing of the material ordered. The manufacturer shall afford the inspector all reasonable facilities, without charge, to satisfy him that the material is being furnished in accordance with this specification. All tests (except product analysis) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

12. Rejection

12.1 Rejections based on requirements specified herein shall be reported to the manufacturer within 30 days after receipt of material by the purchaser.

TABLE 1 Chemical Requirements

	Composition, %	
	Heat Analysis	Product Analysis
Carbon	0.28-0.55	0.25-0.58
Manganese, min	0.60	0.57
Phosphorus, max	0.040	0.048
Sulfur, max	0.050	0.058

TABLE 2 Hardness Requirements

Bolt or Stud Diameter, in.	Hardness	
	Brinell Hardness Number	Rockwell C
¼ to 1, incl	255 to 321	25 to 34
Over 1 to 1½, incl	223 to 285	19 to 30
Over 1½ to 3, incl	183 to 235	...

TABLE 3 Tensile Requirements for Coarse-Thread Full-Size Bolts and Studs

Bolt or Stud Diameter, in.	Threads per inch ^A	Stress Area, in. ^{2B}	Tensile Load, min, lbf ^C	Proof Load, Length Measurement Method, lbf ^C	Alternative Proof Load, Yield Strength Method (0.2 % Off-set), lbf ^C
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
¼	20	0.0318	3 800	2 700	2 900
⅝	18	0.0524	6 300	4 450	4 800
¾	16	0.0775	9 300	6 600	7 100
7/16	14	0.1063	12 750	9 050	9 800
½	13	0.1419	17 050	12 050	13 050
⅞	12	0.182	21 850	15 450	16 750
⅝	11	0.226	27 100	19 200	20 800
¾	10	0.334	40 100	28 400	30 700
7/8	9	0.462	55 450	39 250	42 500
1	8	0.606	72 700	51 500	55 750
1⅛	7	0.763	80 100	56 450	61 800
1¼	7	0.969	101 700	71 700	78 500
1⅝	6	1.155	121 300	85 450	93 550
1½	6	1.405	147 500	104 000	113 800
1¾	5	1.90	171 000	104 500	110 200
2	4½	2.50	225 000	137 500	145 000
2¼	4½	3.25	292 500	178 750	188 500
2½	4	4.00	360 000	220 000	232 000
2¾	4	4.93	443 700	271 150	286 000
3	4	5.97	537 300	328 350	346 200

^A For 8 threads per inch in sizes 1½ to 1⅞ in., incl, stresses of 105,000 psi (725 MPa), 74,000 psi (510 MPa), and 81,000 psi (560 MPa) shall be used for calculating the values in columns 4, 5, and 6 respectively.

^B Stress area calculated from the formula:

$$A_s = 0.7854 [D - 0.9743/n]^2$$

where:

A_s = stress area,

D = nominal diameter, and

n = threads per inch.

^C Values tabulated are based on the following:

Bolt Size, in.	Column 4, psi (MPa)	Column 5, psi (MPa)	Column 6, psi (MPa)
¼ to 1, incl	120 000 (825)	85 000 (585)	92 000 (635)
1½ to 1⅞, incl	105 000 (725)	74 000 (510)	81 000 (560)
1¾ to 3, incl	90 000 (620)	55 000 (380)	58 000 (400)

TABLE 4 Tensile Requirements for Fine-Thread Full-Size Bolts and Studs

Bolt or Stud Diameter, in.	Threads per inch	Stress Area, in. ^{2A}	Tensile Load, min, lbf ^B	Proof Load, Length Measurement Method, lbf ^B	Alternative Proof Load, Yield Strength Method (0.2 % Off-set), min, lbf ^B
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
¼	28	0.0364	4 350	3 100	3 500
⅝	24	0.0580	6 950	4 950	5 350
¾	24	0.0878	10 550	7 450	8 100
7/16	20	0.1187	14 500	10 100	10 900
½	20	0.1599	19 200	13 600	14 700
⅝	18	0.203	24 350	17 250	18 700
¾	18	0.256	30 700	21 750	23 500
¾	16	0.373	44 750	31 700	34 300
¾	14	0.509	61 100	43 250	46 800
1	12	0.663	79 550	56 350	61 000
1⅝	12	0.856	89 900	63 350	69 350
1¼	12	1.073	112 650	79 400	86 900
1⅝	12	1.315	138 100	97 300	106 500
1½	12	1.581	166 000	117 000	128 000

^A See footnote^B below Table 3.^B See footnote^C below Table 3.

TABLE 5 Tensile Requirements for Specimens Machined from Bolts and Studs

Bolt or Stud Diameter, in.	Tensile Strength, min, psi (MPa)	Yield Strength, min, psi (MPa)	Elongation in 4 D min, %	Reduction of Area, min, %
¼ to 1, incl	120 000 (825)	92 000 (635)	14	35
Over 1 to 1½, incl	105 000 (725)	81 000 (560)	14	35
Over 1½ to 3, incl	90 000 (620)	58 000 (400)	14	35

TABLE 6 Sample Sizes and Acceptance Numbers for Inspection of Hot Dip or Mechanically Galvanized Threads

Lot Size	Sample Size ^{A, B}	Acceptance Number ^A
2 to 90	13	1
91 to 150	20	2
151 to 280	32	3
281 to 500	50	5
501 to 1 200	80	7
1 201 to 3 200	125	10
3 201 to 10 000	200	14
10 001 and over	315	21

^A Sample sizes of acceptance numbers are extracted from "Single Sampling Plan for Normal Inspection" Table IIA, MIL-STD-105D.^B Inspect all bolts in the lot if the lot size is less than the sample size.

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